# Christine A. Shoemaker

## EDUCATION

1962-66 B.S. (Mathematics), University of California
1965-66 Enrolled at Universität Göttingen, Germany (studying Mathematics in German language)
1971 Ph.D. in Mathematics, University of Southern California
Ph.D. Thesis Supervisor: Richard Bellman (Mathematics)
Ph.D. Minor Advisor: Gerhard Tintner (Economics)
Specialty: Nonlinear Optimal Control (with application to Environment)

## ACADEMIC POSITIONS

2002-present **Joseph P. Ripley Professor of Engineering,** Cornell University

1972-Present **Professor** (1985- ), Associate Professor (1979-1985),
Assistant Professor (1972-79)
School of Civil and Environmental Engineering, Cornell University
Hollister Hall, Ithaca, New York 14853-3501
(607) 255-9233 cas12@cornell.edu

1985-1988 **Chairman, Department of Environmental Engineering**, Cornell University.
Responsibilities: prepare faculty promotion cases, supervise hiring of faculty, set salaries, negotiate for department resources with the Dean, assign resources and teaching/administrative responsibilities. The Environmental Engineering Department had 18 faculty members and shared with the Structural Engineering Department (12 faculty members) teaching and supervision of about 130 graduate students and 100 undergraduate students in the School of Civil and Environmental Engineering.

1983-1985 **Associate Director, School of Civil & Environmental Engineering**, Cornell University.
Responsibilities: supervise CEE advising of undergraduate students, oversee CEE curriculum modifications, personally advise students in academic difficulty, prepare ABET accreditation documents.

2001-2002 **Humboldt Research Prize Fellow,** Rheinisch-Westfälische Technische Hochschule Aachen, Germany

1988 **Visiting Fellow**, Department of Applied Biology
University of Cambridge, Cambridge, England

1976-1977 **Visiting Systems Ecologist**, Division of Biological Control,
University of California, Berkeley

## RESEARCH INTERESTS

Prof. Shoemaker's research focuses on optimization, modeling and statistical analyses of problems arising in environmental and water resource management. This includes development of numerically efficient algorithms utilizing high performance computing and algorithm application to environmental problems. Her early work focused on ecological analyses designed to reduce the use of pesticides for source control of water and soil pollution. Her more recent work has focused on modeling and optimization of physical and biological methods for remediation of contaminated groundwater and management of contaminant transport in watersheds.

## HONORS AND AWARDS

***Joseph P. Ripley Professor of Engineering***, an endowed chair awarded by Cornell University in 2002.[1]

***Fellow, American Geophysical Union,*** status given to only 0.1%/year of the members of the American Geophysical Union. *Citation*: *For her pioneering contributions in research and graduate education in the area of water quality management, including modeling and optimization algorithm development for pesticide control and for physical and biological methods of groundwater remediation*

***Humboldt Research Prize*** for senior scientists, from A. von Humboldt Foundation in Germany, 2001. "*The Humboldt prize is awarded to Prof. Christine Shoemaker because of her years of research and leadership in the area of quantitative analysis of environmental problems and for her development of computationally efficient methods for analyzing these problems…"* (The only award given in Civil Engineering in 2001.)

***Julian Hinds Award***, ***1999*** American Society of Civil Engineers (highest award given by the Water Resources Planning and Management Division in ASCE) *Citation: "for her leadership and research in ecosystems management, water resources systems analysis, and groundwater modeling and protection"* (Only one award given per year.)

***Offered Sollenberger Endowed Chair, Princeton University 1995*** This is the only endowed chair controlled by Civil Engineering and Operations Research at Princeton. Professor Shoemaker declined this chair offer to stay at Cornell.

***Fellow***, ***1996*** American Society of Civil Engineers

***Distinguished Educator Award, 1991*** from the Society of Women Engineers (SWE). This is a national award given because *"she has established herself as a competent and committed teacher, as an outstanding and productive researcher, as a successful administrator, and as a champion and role model for women in the field of engineering."* (Only one award given per year.)

***Keynote (Plenary) Speaker*** at the following international meetings:
International Association of Hydrogeologists' Congress, Adelaide, Australia, November, 1994.
Mathematical Association of America, San Diego, 1997
Society for Industrial and Applied Mathematics (SIAM), Geosciences Conference, 1997
McMaster Optimization Conference, Canada, 2004 (future invitation)

Elected "***Life Member***" of Clare Hall, University of Cambridge, Cambridge, England, in 1990

***Fellowships/Scholarships***: University of California Regents' Scholarship 1962-66 (UC's most competitive undergraduate scholarship) and National Institute of Health Fellowship 1966-67, for graduate study at the University of Southern California.

***Mathematics Department Citation*** for excellent academic performance, University of California, Davis, 1966

[1] There are relatively few endowed professorships at Cornell University. In CEE, there are currently only four endowed professorships, and two of those were awarded years after the professor had been elected to the NAE.

**SELECTED NATIONAL AND INTERNATIONAL ACTIVITIES**

**Member**, Board of Scientific Counselors, Agency of Toxic Substances and Disease Registry, which has been established by Superfund legislation (*Appointed by U.S. Secretary of Health, Dr. Donna Shalala*) 1994-1998.

**Associate Editor,** *Optimization and Engineering* 1999-present

**Board of Directors of CUAHSI** U.S. University Consortium on Hydrologic Science) 2002-present.

**Founding Chairperson**, ASCE, Water Resource Planning and Management Division's Standing Committee on Groundwater Management *(Prof. Shoemaker wrote a proposal to ASCE WRPM Division EXCOM to establish this new standing committee, and served as Chair for three terms, 1996-1999)*

**Co-Chairman** (with Professor A. Zehnder, Zurich) of International Groundwater Contamination Project for Scientific Council on Problems in the Environment (SCOPE) (1987-1996). *(Prof. Shoemaker helped organize workshops in Stanford (1989), Thailand (1991), Costa Rica (1993), Eastern Europe (1994), Australia (1994), China (1995). These workshops were funded by proposals Prof. Shoemaker wrote with SCOPE staff to U.N. Environment Program and by regional funds.)*

**Member**, Hydrology Section Award (formerly Horton Award) selection committee 2003, American Geophysical Union (AGU) Committee on Groundwater (1997-present) and co-Chair of AGU fall 2001 and Fall 2003 sessions on optimization of groundwater and surface water management.

**Member**, National Research Council Subcommittee on Utilization of Science, Engineering and Technology of the Committee to Evaluate the Science, Engineering, and Health Basis of the Department of Energy's Environmental Management Program, 1995

**Invited Speaker** (Plenary Session) Society of Industrial and Applied Mathematics (SIAM) Symposium on Industrial Applications of Control Theory, San Diego, 1994

**Invited Speaker** Supercomputing '93, Environmental Applications Forum, Seattle, 1993

**Member**, U.S. National Committee for SCOPE through Environmental Studies Board of the National Research Council (1984-1987).

**Co-Chairman** (with Professor S. Levin, Cornell University) of Special Year in "Mathematical Analysis of Environmental Issues," Center for Applied Mathematics, Cornell University (1987-1988). This involved two Cornell conferences on ecological modeling and on environmental modeling

**Panel Member,** National Research Council Committee on "Local and State Strategies for Groundwater Quality Protection" (1985-1986).

**Panel Member,** Food and Agriculture Organization (FAO)-United Nations in Rome, Italy, Expert Panel on Pest Management (1983-1987).

**Associate Editor,** *Journal of Mathematical Analysis and Applications* (1981-1984).

**Co-Organizer** of a NATO Conference on Resource Management, Parma, Italy, July 31-August 5, 1978.

**Panel Member**, National Research Council Study on Pest Control (1973-1975).

**Research Projects in Current Period:**

**1**."Improving Calibration, Sensitivity and Uncertainty Analysis of Data-Based Models of the Environment, "$350,000, 4/1/03 –3/30/06, [from Environmental Engineering program in Engineering. Directorate] **National Science Foundation**

In this project, new function approximation (serial) algorithms developed by my group will be applied to the problem of calibration of complex, nonlinear, computationally expensive, environmental models. As an example, the function approximation algorithm will be used with the transport model for anaerobic bioremediation of chlorinated ethenes by my group to assess the model's ability to fit field data. The methodology developed also permits the analysis of multivariate sensitivity and uncertainty analysis.

**2.** "Multi-Algorithm Parallel Optimization of Costly Functions", $380,000, 7/2003-6/2006 [from Advanced Computing Research Program in the Computer and Information Science Directorate] **National Science Foundation**.

The objective of this project is to develop an effective parallel algorithm for finding near optima for costly nonconvex black box functions f(x) for x in $D \subset R^d$ when derivatives of f(x) are unavailable. This methodology focuses on "costly" f(x), i.e. the CPU time to evaluate f(x) once can range from many minutes up to many hours or days. Such problems arise in many areas of science and engineering, including the optimization of nonlinear systems that are described by partial differential equations. Our approach is to design a coarse-grained procedure that is scalable and robust for a variety of application problems and computing environments. The proposed procedure iteratively uses function approximation algorithms. The algorithm will be applied to a range of difficult test problems and to costly real engineering functions. These applications come from the PI's own research projects on environmental pollution and safety of drinking water.

**3.** GAANN Fellowships for Computational Analysis of Groundwater Bioremediation, $306,000, 8/15/00-8/15/04, **Department of Education**

These fellowships are for students focusing on computational analysis of groundwater bioremediation. The Ph.D. students can be from the graduate fields of Civil and Environmental Engineering, Chemical Engineering, Computer Science or from other related engineering fields. The students are given opportunity to develop a background in microbiology, chemistry and computational methods and to apply this background to their research on bioremediation.

**4.** Systematic Monitoring, Modeling, and Evaluation of Management in Cannonsville Reservoir Basin II, $265,591, 9/01/01-3/31/03, **Environmental Protection Agency** funding through Delaware County, N.Y. *(Shoemaker and Porter are PI's on this expired project, but a request has been verbally approved for $100,000 for continuation funding for me (Shoemaker, sole PI) for the coming year. There are difficulties between contract people, which are expected to be eventually overcome.)*

**RECENT CONSULTING**

HydroMath, LLC 1998-present
Argonne National Laboratory, Department of Energy, 1994-1997

**MEMBERSHIP IN CORNELL UNIVERSITY GRADUATE FIELDS[2]**

Civil and Environmental Engineering
Operations Research
Applied Mathematics
Agricultural and Biological Engineering
Ecology and Systematics

**Ph.D. THESES SUPERVISED AT CORNELL UNIVERSITY**

Turgeon, Andre, "Optimal Operation of a Hydro-Steam Power System", Ph.D. School of Civil and Environmental Engineering, June 1975. *(Dr. Turgeon is a chaired professor in the Industrial Engineering Department at the Ecole Polytechnique ,University of Montreal and worked for years in research with a major hydropower company)*

Rovinsky, Robert, "Models to Evaluate the Economic and Environmental Effects of Restricting Insecticide Use on Cotton and Corn", Ph.D. School of Operations Research, January 1977. *(Dr. Rovinsky has served in senior administrative positions in USDA and other government agencies in areas related to computing and operations research. He is now in private consulting.)*

Smith, Gary, "Variable Development Rate Models of Poikilotherm Populations: Model Definition, Parameter Estimation and Error Analysis", Ph.D., Ecology and Systematics, January 1978. *(Unknown, but presumed to be in consulting.)*

Onstad, David, "Options for Design and Control in the Management of a Tortricid Leafroller," Ph.D., Department of Entomology, August, 1985. *(Professor of Entomology, University of Illinois)* [Shoemaker was co-Chair with Prof. Reissig in Entomology in Cornell-Geneva.]

Hooper, Richard, "The Chemical Response of an Acid-Sensitive Headwater Stream to Snowmelt and Storm Events: A Field Study and Simulation Model", Ph.D., School of Civil and Environmental Engineering, January 1986. *(Senior research scientist with U.S. Geological Survey, National Co-ordinator for Water Quality in USGS, Associate Editor for Water Resources Research 1991-1995, and currently Acting President of the Consortium of Universities CUAHSI )*

Stanley, Bruce, "Empirical and Mathematical Approaches to the Management of the apple Maggot", Ph.D., Department of Entomology, August 1988. *(Senior Research Scientist with Dupont Corporation doing statistical analyses of pesticides.)* [Prof. Shoemaker was co-Chair of his Ph.D. with Prof. Reissig in Entomology at Cornell-Geneva.]

[2] Membership in a graduate field enables a professor to be the major supervisor of Ph.D. students in this field. Membership is based upon election by faculty in the graduate field.

**Ph.D. THESES SUPERVISED AT CORNELL UNIVERSITY (continued)**

Hoy, Casey, "Stimulating Intraplant Spatial Dynamics of Lepidoptera on Cabbage to Predict Feeding Damage," Ph.D. Department of Entomology, January, 1988. *(Professor of Entomology, Ohio State University)* [Prof. Shoemaker was co-Chair with Prof. Reissig in Entomology at Cornell-Geneva.]

Johnson, Sharon A., "Spline Approximation in Discrete Dynamic Programming with Application to Stochastic Multi-Reservoir Systems," Ph.D., School of Operations Research and Industrial Engineering, January 1989. *(Associate Professor, School of Management, Worcester Polytechnic Int.)*

Liao, Li-Zhi, "Numerically Efficient Algorithms for Unconstrained and Constrained Differential Dynamic Programming in Discrete-Time, Nonlinear Systems" Ph.D., School of Operations Research and Industrial Engineering, Cornell University, August, 1990. *(Associate Professor of Mathematics, Baptist College in Hong Kong)*

Chang, Liang-Cheng, "The Application of Constrained Optimal Control Algorithms to Groundwater Remediation, Ph.D., School of Civil and Environmental Engineering, Cornell University, August 1990. *( Professor of Civil Engineering, Chao Tung University, Taiwan)*

Culver, Teresa B. "Dynamic Optimal Control of Groundwater Remediation with Management Periods: Linearized and Quasi-Newton Approaches," Ph.D., School of Civil and Environmental Engineering, Cornell University, August, 1991. *(Associate Professor of Civil Engineering, University of Virginia. Winner of NSF Career award and of ASCE Huber Award for young researchers)*

Buydens, Walter J.R., "Irrigation Management Optimization Incorporating Equity and Crop Simulation," Ph.D., School of Civil and Environmental Engineering, Cornell University, May 1992. *(Director French, Belgian, and Dutch offices of ERM, a large Environmental Consulting Company)*

Eschenbach, Elizabeth B., "Parallel Processing of Stochastic Dynamic Programming With Continuous State Variables with Application to Reservoir Operation," Ph.D., School of Civil and Environmental Engineering, Cornell University, January, 1994. *(Associate Professor of Environmental Resource Engineering, Humboldt State University, California)*

Whiffen, Gregory, "Optimal Control for Deterministic and Uncertain Groundwater Remediation," Ph.D., School of Civil and Environmental Engineering 1995. *(Independent consulting on applications of optimization to environmental problems and to space exploration—working now primarily for Jet Propulsion Laboratory. At Cornell he won a DOE Computational Sciences Fellowship.)*

Minsker, Barbara, "Dynamic Optimal Control of In Situ Bioremediation of Groundwater," Ph.D. School of Civil and Environmental Engineering, 1995. *(Assistant Professor of Civil Engineering, University of Illinois. She won a PECASE award from DOD and a career award from NSF. At Cornell she had an NSF fellowship She won an ASCE Huber award..)*

Mansfield, Christopher, "Time-Varying Optimal Control of Groundwater Remediation in Unconfined Aquifers,", Ph.D., School of Civil and Environmental Engineering 1997. *(He later attended law school and is now in a law practice. He won a DOE Environmental Fellowship and a McMullen fellowship while at Cornell.)*

**Ph.D. THESES SUPERVISED AT CORNELL UNIVERSITY (continued)**

Yoon, Jae-Heung, "Optimal Design of Groundwater in situ Bioremediation Using Evolutionary Algorithms," Ph.D., School of Civil and Environmental Engineering, Cornell Univ. 1997. *(He works for a government-funded research agency in Korea.)*

Willis, Matthew, "Modeling, Optimization and Sensitivity Analysis of Reductive Dechlorination with Competition in Groundwater", Ph.D., School of Civil and Environmental Engineering, Cornell University, 2000 *(He is currently working as a software developer.)*

Fan, Daisy, "Application of Experimental Design to Improve Computational Efficiency of Stochastic Dynamic Programming with Applications to Water Resource Management", Ph.D. School of Civil and Environmental Engineering, Cornell University, 2001. *She is an Assistant Professor in Computer Science Department at Cornell University.*

Rohde, Raju, "Computationally Efficient Algorithms for Optimization of Remediation and Bioremediation of Groundwater," Ph.D. School of Civil and Environmental Engineering, Cornell University, 2001. *He is a German citizen working for Dorch Consult in Munich on groundwater analyses.*

Benaman, Jennifer "A Systematic Approach to Uncertainty Analysis for a Comlex Distributed Watershed Model", Ph.D. School of Civil and Environmental Engineering, Cornell University, January 2003. *She heads the Austin Branch Office of Quantitative Environmental Analysis, a consulting firm.*

**CURRENT SUPERVISION OF M.S. /Ph. D. STUDENTS**

Pradeep Mugunthan, Bryan Tolson, Laura DiPalermo, Jose Aponte, Rommel Regis (Fellow in Intelligent Information Systems Institute, Cornell)

**RECENT POSTDOCTORAL SUPERVISION**

Matthew Willis 2000-2001
Christopher Mansfield 1997-2000
Bijaya Shrestha 1995-1997

**PROFESSIONAL SOCIETY MEMBERSHIPS**

American Geophysical Union (AGU)
American Society of Civil Engineers (ASCE)
Institute for Operations Research and Management Science (INFORMS)
Institute of Electrical and Electronics Engineers (IEEE)
Association for Computing Machinery (ACM)

**PATENT HELD**

"Weighted Nonlinear Feedback for Optimal Control under Uncertainty with Application to Groundwater Remediation," by Whiffen and Shoemaker (U.S. Patent 5,468,088)

## SELECTED RECENT CORNELL ACTIVITIES

**Project Director, GAANN** Fellowship Program in Computational Biology for Environmental Bioremediation 2000-2004 (for Ph.D. students in Computer Science, Chemical Engineering, or Civil and Environmental Engineering graduate fields)

**Founding Member** of the Faculty for Computer and Information Science (FCI) 2000-present

**Moderator and Co-organizer** (with Dean of the Faculty, R. Cooke) of university-wide Faculty Forum on Computing, September, 1999

**Engineering College Committee on Climate** (to develop a supportive environment for faculty and graduate students with emphasis on women and underrepresented minorities) 1998

**Founding Chairperson**, Status of Women Committee for College of Engineering (1986-1995)

**Member** (twice elected by university faculty) of Executive Committee for the Cornell Theory Center (for supercomputing research)

**Subject Area Representative for EWRS (Environmental and Water Resource Systems Engineering)-**which involves processing all Ph.D. and M.S. graduate applications to EWRS, and organizing follow-up interviews and financial aid packages.

**Co-Chair of Engineering Women Faculty Committee** 2003-2004

*(Professor Shoemaker was also a member of a large number of University Committees, not listed here)*

**PUBLICATIONS (in Journals and Books)**

- Shoemaker, C.A., "Optimization of Agricultural Pest Management I: Biological and Mathematical Background," **Mathematical Biosciences,** 16, 143-175, 1973.

- Shoemaker, C.A., "Optimization of Agricultural Pest Management II: Formulation of a Control Model," **Mathematical Biosciences**, 17, 357-365, 1973.

- Shoemaker, C.A., "Optimization of Agricultural Pest Management III: Results and Extensions of a Model," **Mathematical Biosciences**, 18, 1-22, 1973.

- Pimentel, D.P. and C.A. Shoemaker, "An Economic and Land Use Model for Reducing Insecticides on Cotton and Corn," **Environmental Entomology**, 3, 10-20, 1974.

- Beck, S.D., et al., **Pest Control: An Assessment of Present and Alternative Technologies, Vol. III: Cotton Pest Control,** National Research Council, Washington, DC, 1975.

- Shoemaker, C.A., "Management Models for Integrated Pest Control -- Formulation and Solution Methodology," pp. 32-39 in **Modeling for Pest Management**, R.L. Tummala, D.H. Haynes and B.A. Croft (eds.), Michigan State University Press, East Lansing, 1976.

- Shoemaker, C.A., "Mathematical Construction of Ecological Models," pp. 75-114 in **Ecosystems Modeling in Theory and Practice**, C.A. Hall and J. Day (eds.), Wiley-Interscience, 1977 (translated into Chinese by C.Z. Yuan and published in China in 1984).

- Shoemaker, C.A., "Pest Management Models of Crop Ecosystems," pp. 545-574 in **Ecosystems Modeling in Theory and Practice,** C.A. Hall and J. Day (eds.), Wiley-Interscience, 1977 (translated into Chinese by C.Z. Yuan and published in China in 1984).

- Huffaker, C.B., C.A. Shoemaker and A.P. Gutierrez, "Current Status, Urgent Needs and Future Prospects of Integrated Pest Management," in **Strategies of Pest Control,** D.P. Pimentel and E.H. Smith (eds.), Academic Press, 1978.

- Pimentel, D.P., C.A. Shoemaker and R. Whitman, et al., "A Systems Approach to Corn Pest Management in New York," **Search**, 8, 1-15, 1978.

- Shoemaker, C.A., C.B. Huffaker and C.E. Kennett, "Integrated Pest Management for Olives," **California Agriculture**, 32, 16-18, 1978.

- Huffaker, C.B., R.F. Smith and C.A. Shoemaker, "Development of an Integrated Pest Management System," Proceedings, **Development of Optimum Crop Production Systems for the Mid-South**, University of Arkansas Press, Fayetteville, 1979.

- Shoemaker, C.A., "Optimal Integrated Control of Alfalfa Weevil Hyper postica (Gylienhal) (Coleptera: curculionidae), **European Plant Protection Organization Bulletin,** 9(3), 305-316, 1979

- Pimentel, D.P., C.A. Shoemaker, E.L. La Due, R.B. Rovinsky and N.P. Russell, **Alternatives for Reducing Insecticides on Cotton and Corn: Economic and Environmental Impact,** Environmental Protection Agency, EPA-600/5-79-007a, August 1979.

- Shoemaker, C.A., "Optimal Timing of Multiple Applications of Pesticides With Residual Toxicity," **Biometrics,** 35, 803-812, 1979.

- Shoemaker, C.A. and M.O. Harris, "The Effectiveness of Soil and Water Conservation Practices in Comparison With Other Methods for Reducing Pesticide Pollution," in **Effectiveness of Soil and Water Conservation Practices for Pollution Control,** D.A. Haith and R.C. Loehr (eds.), Environmental Protection Agency, EPA-600/3-79-106, October 1979.

- Shoemaker, C.A., "Optimal Management of an Alfalfa Ecosystem," in **Pest Management,** G.A. Norton and C.S. Holling (eds.), Pergamon Press, Oxford, 1979.

- Shoemaker, C.A., C.B. Huffaker and C.E. Kennett, "A Systems Approach to the Integrated Management of Olive Pests," **Environmental Entomology,** 8, 182-189, 1979.

- Rovinsky, R.B., C.A. Shoemaker and M. and M.J. Todd, "Determining Optimal Use of Resources Among Regional Producers Under Differing Levels of Cooperation," **Operations Research,** 28, 859-866, 1980.

- Rovinsky, R.B. and C.A. Shoemaker, "The Optimal Distribution of Crop Production Under Differing Levels of Farmer Cooperation: An Example Using Cotton," pp. 179-192 in **Operations Research in Agriculture and Water Resources,** D. Yaron and C. Tapiero (eds.), North-Holland Publishing Co., Amsterdam, 1980.

- Ruesink, W.C., C.A. Shoemaker, A.P. Gutierrez and W.G. Fick, "The Systems Approach to Research and Decision Making for Alfalfa Pest Control," pp. 217-247 in **New Technology of Pest Control,** C.B. Huffaker (ed.), John Wiley & Sons, Inc., 1980 (translated into Chinese by C.Z. Yuan and published in China in 1984).

- Shoemaker, C.A., "The Role of Systems Analysis in Integrated Pest Management," pp. 26-49 in **New Technology of Pest Control,** C.B. Huffaker (ed.), John Wiley & Sons, Inc., 1980 (translated into Chinese by C.Z. Yuan and published in China in 1984).

- Shoemaker, C.A., "The Application of Dynamic Programming and Other Optimization Methods to Pest Management," **IEEE Transactions Automatic Control,** 26, 1125-1132, 1981.

- Rovinsky, R.B. and C.A. Shoemaker, "Operations Research: Applications in Agriculture," pp. 151-174 in **Operations Research: Mathematical Models,** A. Goldman (ed.), American Mathematics Society, 1981.

- Shoemaker, C.A., "Optimal Integrated Control of Univoltine Pest Populations With Age Structure," **Operations Research,** 30, 40-61, 1982.

- Shoemaker, C.A. and D.W. Onstad, "An Optimization Analysis of the Integration of Biological, Cultural and Chemical Control of Alfalfa Weevil," **Environmental Entomology,** 12, 286-295, 1983.

- Shoemaker, C.A., "Integrating Economic Analysis With Population Modeling," pp. 154-159 in Pest Management Problems, Proceedings, 10th International Congress of Plant Protection, Brighton, England, Levenham Press, Ltd., Suffolk, England, 1983.

- Osawa, A., C.A. Shoemaker and J.R. Stedinger, "A Stochastic Model of Balsam Fir Development and Its Use in Spruce Budworm Control," **Forest Science,** 29, 478-490, 1983.

- Fleming, R.A., C.A. Shoemaker and J.R. Stedinger, "A Statistical Analysis of Regional Dynamics of Unsprayed Budworm (Leopidoptera: Tortricidae) Populations," **Environmental Entomology,** 12, 707-713, 1983.

- Leighton, J.P. and C.A. Shoemaker, "An Integer Programming Analysis of the Regionalization of Wastewater Treatment and Collection Systems," **Water Resources Research,** 20, 671-681, 1984.

- Fleming, R.A., C.A. Shoemaker and J.R. Stedinger, "An Assessment of the Impact of Large Scale Spraying Operations on the Regional Dynamics of Spruce Budworm Populations," **Canadian Entomologist,** 116, 633-644, 1984.

- Shoemaker, C.A., "Deterministic and Stochastic Analyses of the Optimal Timing of Multiple Applications of Pesticides With Residual Activity," in **Pest and Pathogen Control: Strategy, Tactics and Policy Models,** G.R. Conway (ed.), Wiley-Interscience Publishers, Chichester, 1984.

- Onstad, D.W. and C.A. Shoemaker, "Management of Alfalfa and the Alfalfa Weevil (Hyper postica Gyll.): An Example of Systems Analysis in Forage Production," **Agricultural Systems,** 14, 1-30, 1984.

- Onstad, D.W., C.A. Shoemaker and B.C. Hansen, "Management of Potato Leafhopper (Empoasca fabae) on Alfalfa With the Aid of Systems Analysis," **Environmental Entomology,** 13, 1046-1058, 1984.

- Hudes, E.S. and C.A. Shoemaker, "A Statistical Analysis of the Impact of Host Species on Spruce Budworm Phenology," **Environmental Entomology,** 13, 1602-1603, 1984.

- Stedinger, J.R., C.A. Shoemaker and R.F. Tenga, "A Stochastic Model of Insect Phenology for a Population With Spatially Variable Development," **Biometrics,** 41, 691-701, 1985.

- Onstad, D.W., W.H. Reissig and C.A. Shoemaker, "Phenology and Management of the Oblique Banded Leafroller (Lepidoptera: Tortricidae) in Apple Orchards," **Journal of Economic Entomology,** 78, 1455-1462, 1985

- Hooper, R.P. and C.A. Shoemaker, "Aluminum Mobilization in an Acidic Headwater Stream: Temporal Variation and Mineral Dissolution Disequilibria," **Science,** 229, 463-465, 1985.

- Hooper, R.P. and C.A. Shoemaker, "A Comparison of Chemical and Isotopic Hydrograph Separation," **Water Resources Research,** 22, 1444-1454, 1986.

- Onstad, D.W., W.R. Reissig and C.A. Shoemaker, "Influence of Apple Cultivar Tree Phenology and Leaf Quality on the Development and Mortality of Chyoristoneura rosacena (Lepidoptera: Tortridae)," **Canadian Entomologist,** 118, 123-132, 1986.

- Shoemaker, C.A., G.E. Smith and R.G. Helgesen, "Estimation of Population Recruitment Rates and Survival From Field Census Data With Applications in Poikilotherm Populations," **Agricultural Systems,** 22, 1-21, 1986.

- Stanley, B.H., W.H. Reissig, W.L. Roelofs, M.R. Schwarz and C.A. Shoemaker, "Timing Treatments for Apple Maggot (Diptera: Tephritidae) Control Using Traps Baited With Synthetic Apple Volatiles," **Journal of Economic Entomology,** 80, 1057-1063, 1987.

- Peterson, M.S., L.W. Lion and C.A. Shoemaker, "Influence of Moisture Content on Sorption and Transport of Trichloroethylene," **Environmental Science and Technology,** 22, 571-578, 1988.

- Shoemaker, C.A., L-Z. Liao, B. Aubert and J.F. Abel, "Optimal Nonlinear Control With Geometrically Nonlinear Finite Element Analysis for Flexible Structures: Some Preliminary Results," in **Computational Mechanics,** A.N. Atluri and G. Yagawa (editors), Springer-Verlag, 1988.

- Hudes, E.S. and C.A. Shoemaker, "An Inferential Method for Modeling Insect Phenology and Its Application to the Spruce Budworm," **Environmental Entomology,** 70, 97-108, 1988.

- Shoemaker, C.A., S. Kanellopoulou, S. Naranjo, M. Cheng and W. Tingey, "Using Models to Identify Cost-Effective Pest Management Programs That Minimize Groundwater Pollution," **N.Y. Food and Life Sciences Quarterly**, 18, 5-8, 1988.

- Hoy, C.W., C.E. McCulloch, C.A. Shoemaker and A.M. Shelton, "Transition Probabilities for Trichoplusia ni (Hubner) Lepidoptera: Noctuidae) Larvae on Cabbage as a Function of Microclimate" **Environmental Entomology** 18, 187-194, 1989.

- Shoemaker, C.A. and S.A. Johnson, "Stochastic Nonlinear Optimal Control of Populations: Computational Difficulties and Possible Solutions," in **Mathematical Approaches to Problems in Resource Management and Epidemiology,** C. Castillo-Chavez, S. Levin and C.A. Shoemaker (editors), Springer-Verlag 1989.

- Shoemaker, C.A., T. Culver, L.W. Lion and S. Peterson, "Analytical Models of the Impact of Two-Phase Sorption on Subsurface Transport of Volatile Chemicals," **Water Resources Research** 745-758, 1990.

- Shoemaker, C.A., T.B. Culver, L.W. Lion, and M.G. Peterson, "Analytical Models of the Impact of Two-Phase Sorption on Subsurface Transport of Volatile Chemicals," **Water Resources Research**, 26, 745-758, 1990.

- Stanley, B.H., W.H. Reissig, C.A. Shoemaker and D.S. Robson, "Foliar Azinphosmethyl Concentration-Exposure Time-Mortality Relationships for the Apple Maggot (Diptera: Tephritidae)," **Journal of Economic Entomology** 82, 895-905, 1990.

- L-Z. Liao and C.A. Shoemaker, "Convergence in Unconstrained Discrete-Time Differential Dynamic Programming" **IEEE Transactions on Automatic Control** 36, 692-706, 1991.

- Culver, T.B., C.A. Shoemaker, and L.W. Lion, "Impact of Vapor Sorption on the Subsurface Transport of Volatile Organic Compounds: A Numerical Model and Analysis," **Water Resources Research**, 27, 2259-2270, 1991.

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